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DETERMINING BY A SINGLE FLOW TEST THE CAPACITY OF A METER AT ALL PRESSURE LOSSES[1]

By Fred. B. Nelson[2]

Standard specifications for water meters[3] as proposed by the Joint Committee of the American and the New England Water Works Associations in regard to capacity, require that new meters shall show a loss of head not exceeding 25 pounds per square inch with rates of flow as listed for the different sizes, and that manufacturers be required to give graphically the capacity of each size of meter from zero to 25 pounds loss of pressure. The minimum of apparatus which must be used in determination of capacities, as well as accuracy, is also specified.

The writer has conducted a fairly thorough series of capacity tests on various sizes and makes of disc meters, devising and assembling the necessary apparatus, and utilizing, naturally, the most convenient method of plotting and comparing results. The references of the specifications to capacity and apparatus especially suggest to the writer the conveniences and advantages of a method of plotting which are believed to be quite generally overlooked by water works men and many engineers in plotting, for study and ready reference, not only meter capacities, but other hydraulic data. The apparatus used was "home-made" and its illustration may be helpful.

At the risk of seeming to repeat some of the points mentioned in a paper presented some time ago, the writer wishes briefly to describe and to illustrate the method, in the hope that the suggestions may prove of value to others on similar work.

The pressure loss in meters in relation to the discharge, like many other hydraulic data, follows a general law, in which one quantity varies directly as the fixed power of another. In this case the pressure loss varies as the square or second power of the discharge. If then, instead of plotting the actual values, say pounds pressure loss for varying cubic feet per minute, we plot the powers of some one number, which correspond to those values, the points will fall on a straight line at a slope of two to one (see fig. 1). This is

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[1] Presented at the Cleveland Convention, June 9, 1921.

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[3] Journal, May, 1921, page 273.

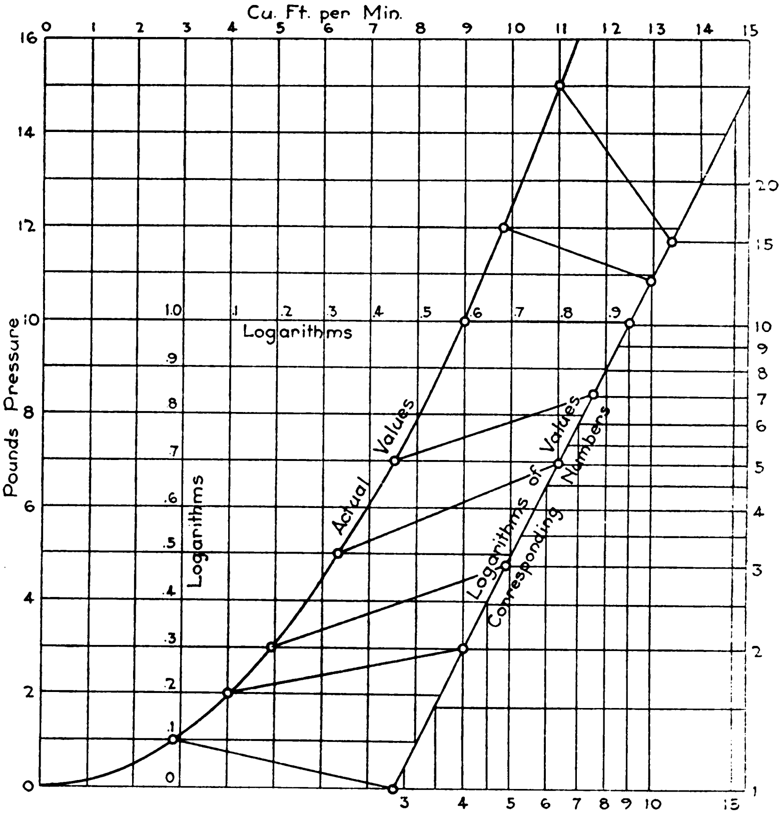


Fig. 1. Comparison of Direct and Logarithmic Plotting in the Case Where Pressure Loss Varies as the Square of the Discharge

Direct plotting of the results of various tests determines the curve of actual or proportional values (Parabola).

Plotting, on the same proportional ruling, the logarithms (powers of 10) corresponding to those values, the points will be found to fall on a straight line whose slope (2 vertical to 1 horizontal) represents the power (2nd) of the discharge in proportion to which the pressure loss varies.

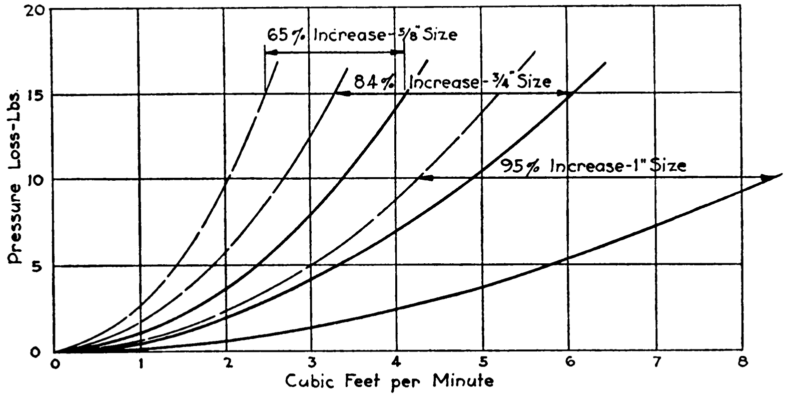
Drawing lines representing values 1 to 10, horizontally and vertically through their corresponding logarithmic ruling on this latter diagram produces the logarithmic ruling shown to the right of the straight line.

Several corresponding points on the two curves have been connected by lines to facilitate comparisons.

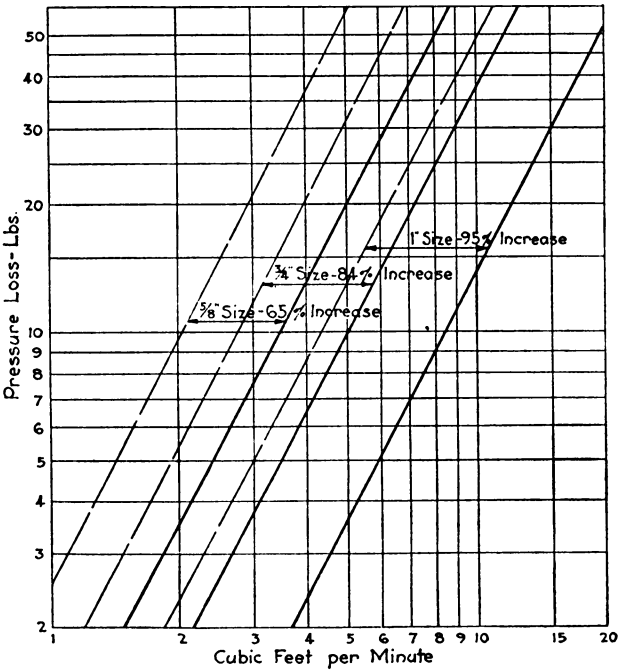
the principle involved in the construction and use of logarithmic paper. On such paper the ruling representing numbers one to ten is so arranged that equal distances horizontally and vertically will be proportionate to the logarithms of those numbers, or as commonly used proportionate to the powers of ten corresponding to those numbers. In other words, a curve showing *values* on logarithmic paper is identical with one showing *powers of ten* corresponding with those values, on straight ruled paper, so that where one value varies as a fixed power of another, the vertical distance of any point on the plotting in either case is a fixed proportion of the horizontal and the curve becomes a straight line drawn at a slope corresponding with that power.

This feature constitutes the main convenience in the use of logarithmic paper. It accounts largely for its extensive use in the plotting or drawing of curves, representing a clas sof laws and formulae in engineering, probably as numerous as those that may be represented by a straight line on straight ruled paper. Such values as discharge of venturi meters, corresponding to various deflections of mercury in the manometer pressure loss in mains of various sizes or their capacity under varying differences of head, the pressure loss of meters at varying rates of flow, and conversely, their capacity under varying pressure differences—all may be determined throughout all ranges by one careful test on each given size of venturi, main or meter. With the results of this one test, plotted on logarithmic paper, the entire range of values is determined by simply drawing through that point a straight line at a slope corresponding with the power by which the one value varies with reference to the other: One to one-half, one to three halves, one to two etc. Conversely, the power by which the one value varies in relation to the other, is shown by two or more tests at different values. The slope of a straight line drawn through the plotted results, shows the power in the formula, by which, with a constant, one value is determined from the other.

In the case of disc meters, the pressure loss varies closely with the square of the discharge, so that on logarithmic paper, with the discharge values plotted horizontally and pressure losses vertically, the performance of a given meter will be represented by a straight line drawn at a slope of two vertically to one horizontally. The only determination necessary is the position of that line, which is fixed by plotting the results of a single test at any one flow, giving values that may be accurately measured. All makes and all sizes



PROPORTIONAL PLOTTING



LOGARITHMIC PLOTTING

FIG. 2. THE SAME METER CAPACITY DATA BY TWO METHODS OF PLOTTING

of disc meters follow the same law and consequently their pressure loss curves are all parallel straight lines, differing in position only, which is determined by the single test of the individual size and make (fig. 2).

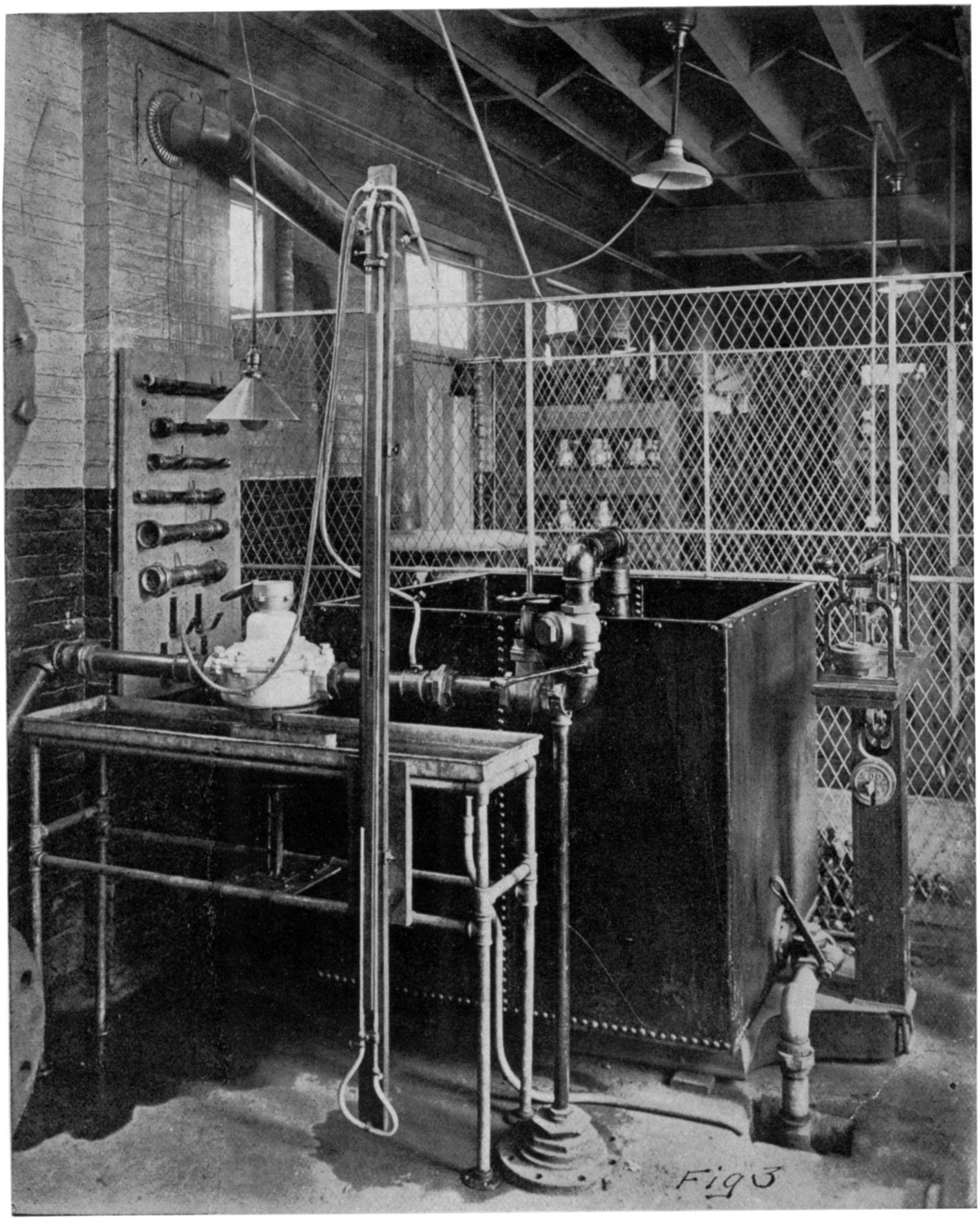


Fig. 3. Home Made Apparatus for Test of Capacity and Pressure Loss

The writer has frequently tested the accuracy of this method by plotting the curve as described and afterward adjusting to a different rate of flow by opening the regulating valve until the indicated pressure loss corresponded with the desired rate by the line so drawn. With this adjustment, the test showed the rate to be within one or two per cent of that desired.

The test of a meter, therefore, as to capacity specification is not a cut and try process, but one involving only one test at any convenient rate at which readings may be easily and accurately taken. It offers one illustration of the many ways in which the method of plotting here noted may be conveniently used.

The apparatus used (fig. 3) consisted essentially of the usual weighing tank for accurate determination of quantities, a hand valve on the outlet for convenient adjustment of the flow, a quick acting valve to obviate introduction of lower flows in starting and stopping the test, and a six-foot mercury U-tube connected between piezometer rings on the inlet and outlet of the meter, with the connecting tubing arranged for expelling air.